Beef Tallow and Emulsifier in Growing-Finishing Pig Diets

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ABSTRACT

Two trials were aimed to evaluate beef tallow in diets with and without emulsifier on performance of pigs at growing-finishing phases. In the first trial, 15 barrows (22.03±0.62 kg) were distributed among three treatments: reference diet; test diet 1 (5% beef tallow) and test diet 2 (10% beef tallow). Beef tallow presented average value of 7130.97 kcal ME/kg. For the performance trail, 30 barrows (24.85±1.18 kg) were distributed among five treatments: T1 – diet with soybean oil and 3230 kcal ME /kg; T2 - diet with beef tallow and 3230 kcal ME/kg; T3 - diet with beef tallow and 3080 kcal ME/kg; T4 - diet with beef tallow, 3080 kcal/kg and 0.1% emulsifier; T5 - diet with beef tallow, 2930 kcal ME/kg and 0.1% emulsifier. Feed conversion was worse in animals fed diet with 3080 kcal ME/kg containing beef tallow and with 2930 kcal ME/kg with beef tallow and emulsifier. For economic availability, animals fed diet with beef tallow and 3230 kcal ME/kg and those fed diet with 3080 kcal ME/kg containing beef tallow and emulsifier, did not differ from animals fed diet with soybean oil, which enables the reduction up to 150 kcal ME/kg be compensated by emulsifier addition.

Key words: animal fat, lipids, soy lecithin, triglycerides.

INTRODUCTION

Lipids are energy sources that have been included in pig diets due to the higher energy content and lower heat increment compared to carbohydrates, being the soybean oil the most widely used due to its availability and composition of long-chain unsaturated fatty acids, being more susceptible to the action of pancreatic lipase. However, the high cost of soybean oil, as well as the offseason price variation motivates the search for alternative lipid sources, such as beef tallow, which is a residue derived from adipose tissue cavity and subcutaneous fat from cattle submitted to slaughter (Pupa 2004). Some studies showed the viability of tallow as a substitute for soybean oil in diets for pigs (Apple et al. 2009a, Park et al. 2009), as well as improving carcass fat quality (Browne et al. 2013).

However, the use of beef tallow is questioned in relation to its efficiency, due to the content

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of long-chain saturated fatty acids which not provide an appropriate relationship between saturated fatty acids and unsaturated fatty acids required for a synergistic response derived from this interaction, resulting in lower digestibility (Mitchaothai et al. 2008). In this sense, aiming to improve the digestibility of saturated fatty acids and the absorption of triacylglycerides, emulsifier additives can be added to diets containing beef tallow. Among the emulsifiers, soybean lecithin is a phospholipid which mode of action consists of reducing the surface tension of immiscible phases of lipids, increasing the digestibility of fat and other lipid compounds (Mitchaothai et al. 2010). Researches evaluating the use of emulsifiers in pig diets are scarce and mainly related to lipid sources of vegetable origin (Overland et al. 1993). In this sense, considering the lower cost of lipid sources such as beef tallow, these additives may be an important nutritional tool to maximize the use of triacylglycerides and reduce the cost of growing-finishing pig diets.

Based on the above, the objective of this research was to evaluate the effects of beef tallow in diets for growing-finishing pigs with or without the addition of emulsifier, on performance, nutrient digestibility of diets, serum triglycerides, carcass characteristics and economic viability.

MATERIALS AND METHODS

The experimental procedures followed the protocols approved by Ethics Committee on Animal Research (CEUA 144/2014) of Federal University of Ceará (UFC).

The experiment was conducted in the Pig Farming Sector of the Federal University of Ceará and divided into two trials; the first trial was aimed to determine the metabolizable energy and digestible nutrients from beef tallow and the second one to evaluate the inclusion of beef tallow with and without addition of emulsifier in diets for growing-finishing pigs.

The first trial was performed using 15 barrows from commercial line with initial weight of 22.03 ± 0.62 kg, alloted in metabolic cages. The animals were distributed in a completely randomized design with three treatments and five replicates. The treatments were: RD - reference diet, TD1 - test diet composed by 95% reference diet and 5% of beef tallow and TD2 - test diet composed by 90% of reference diet and 10% of beef tallow. The reference diet (Table I) was based on corn and soybean meal, formulated to meet the requirements of nutrients and metabolizable energy, according to the recommendations of Rostagno et al. (2011). Total collection of feces and urine method was performed, being the 12-day experimental period with seven days for adaptation to diets and cages and five days of collection of feces and urine. Samples were subsequent analyzed for dry matter (DM), mineral matter (MM), crude protein (CP), ether extract (EE) and gross energy (GE), according to AOAC (1995). After the analysis, it was obtained the coefficient of digestibility of nutrients and metabolizable energy of beef tallow (Sakomura and Rostagno 2007).

In the performance trial, a total of 30 barrows of commercial line, with initial weight of 24.85 ± 1.18 kg, was distributed in a randomized block design, based on the initial weight, with five treatments and six replicates. The treatments were defined by isonutrient experimental diets (Table I), formulated according to the nutritional requirements for growing phase 1 (70 to 90 days of age), growing phase 2 (90 to 105 day old) and finishing phase (105 to 150 days of age), considering feedstuff composition as proposed by Rostagno et al. (2011). For beef tallow, energy value obtained in the metabolism trial was used. The experimental diets differed in lipid source, metabolizable energy level (ME) and with or without emulsifier addition, as follows: T1 – control diet with soybean oil inclusion and 3230 kcal ME/kg; T2 - diet with beef tallow inclusion and 3230 kcal ME/kg; T3 - diet with beef

TABLE I

Composition, nutritional and energy contents of the experimental diets for growing and finishing pigs.

Ingredients (%)	RD	Growing 1 (70 a 90 days of age)					Growing 2 (90 a 105 days of age)					Finishing (105 a 150 days of age)				
		T1	T2	T3	T4	T5	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5
Corn grain	74.32	64.39	64.61	56.50	56.50	45.42	66.85	67.07	59.34	59.34	47.88	70.22	70.44	62.53	62.53	51.20
Soybean meal	22.45	22.56	22.69	22.06	22.06	19.69	18.37	18.50	18.09	18.09	15.50	13.63	13.76	13.24	13.24	10.85
Wheat bran	0.00	8.24	7.77	13.63	13.63	25.90	10.42	9.95	15.00	15.00	28.10	11.83	11.36	16.80	16.80	29.45
Soy oil	0.20	1.88	0.00	0.00	0.00	0.00	1.88	0.00	0.00	0.00	0.00	1.88	0.00	0.00	0.00	0.00
Beef tallow	0.00	0.00	2.00	2.00	2.00	2.00	0.00	2.00	2.00	2.00	2.00	0.00	2.00	2.00	2.00	2.00
Dicalcium phosphate	1.50	1.06	1.06	0.99	0.99	1.09	0.73	0.74	0.90	0.90	0.75	0.65	0.65	0.59	0.59	0.70
Limestone	0.50	0.76	0.76	0.79	0.79	0.84	0.68	0.67	0.69	0.69	0.76	0.65	0.65	0.79	0.79	0.72
L-Lysine	0.25	0.26	0.26	0.26	0.26	0.29	0.24	0.24	0.24	0.24	0.28	0.30	0.30	0.31	0.31	0.34
DL–Methionine	0.08	0.06	0.06	0.07	0.07	0.07	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05
Vitamin-mineral suppl.[1]	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
Salt	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Inert[2]	0.00	0.10	0.10	3.00	2.90	3.90	0.10	0.10	3.00	2.90	3.90	0.10	0.10	3.00	2.90	3.90
Lipidol®[3]	0.00	0.00	0.00	0.00	0.10	0.10	0.00	0.00	0.00	0.10	0.10	0.00	0.00	0.00	0.10	0.10
Total	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Cost (R$/kg)	0.99	1.01	1.00	0.97	1.00	0.96	0.96	0.95	0.93	0.96	0.91	0.92	0.91	0.88	0.91	0.88
Chemical composition and energetic																
Metabolizable energy (kcal/kg)	3230	3230	3230	3080	3080	2930	3230	3230	3080	3080	2930	3230	3230	3080	3080	2930
Crude protein (%)	16.82	16.82	16.82	16.82	16.82	16.82	15.43	15.43	15.43	15.43	15.43	13.83	13.83	13.83	13.83	13.83
Crude fiber (%)	2.48	3.09	3.06	3.44	3.44	4.29	3.12	3.09	3.41	3.41	4.32	3.06	3.03	3.38	3.38	4.26
Calcium (%)	0.63	0.63	0.63	0.63	0.63	0.68	0.51	0.51	0.56	0.56	0.56	0.47	0.47	0.52	0.52	0.52
Available phosphorus (%)	0.31	0.31	0.31	0.31	0.31	0.36	0.25	0.25	0.29	0.29	0.29	0.23	0.23	0.23	0.23	0.28
Lysine digestible (%)	0.93	0.93	0.93	0.93	0.93	0.93	0.82	0.82	0.82	0.82	0.82	0.76	0.76	0.76	0.76	0.76
Methionine+Cystine digestible (%)	0.55	0.55	0.55	0.55	0.55	0.55	0.49	0.49	0.49	0.49	0.49	0.46	0.46	0.46	0.46	0.46

RD: Reference diet. [1]Mineral and vitamin supplement - amount per kg of product: vitamin A - 2500000 IU; vitamin D3 - 500000 IU; biotin - 50 mg; choline - 50 mg; niacin - 10000 mg; calcium pantothenate - 3000 mg; vitamin B12 - 7 mg; vitamin B2 - 1800 mg; vitamin E - 7500 mg; vitamin K3 - 1000 mg; iron - 40000 mg; copper - 35000 mg; manganese - 20000 mg; zinc - 40000 mg; cobalt - 360 mg; iodine - 840 mg; selenium - 120 mg. [2]Kaolin. [3]Soy lecithin 50%.

tallow inclusion and 3080 kcal ME/kg; T4 - diet with beef tallow inclusion, 3080 kcal ME/kg and addition of 0.1% emulsifier; T5 - diet with beef tallow inclusion, 2930 kcal ME/kg and addition of 0.1% emulsifier. It was used the emulsifier Lipidol®, consisted of soy lecithin (50%). Water and feed were offered ad libitum to the animals during all experimental period.

To measure the performance variables, the animals and diets were weighed at the beginning and end of each phase. The feed leftovers were collected and quantified daily to calculate the feed intake. Based on the data feed intake and weight of the animals, it was determined daily feed intake, daily weight gain and feed conversion ratio, considering the period 1 (70-90 days), period 2 (70-105 days) and total period (70 to 150 days).

The coefficients of digestibility of nutrients and energy of diets were determined at the beginning of finishing phase, through the method of partial feces collection, being the Celite 545 used as an external marker. The adaptation period was represented by the first three days, followed by four days of feces collection, which are directly collected in the rectum of the animal, once a day. After the collection period, analyzes were performed for DM, MM, CP, EE, GE and acid insoluble ash (AIA) in faces samples and diets. The acid insoluble ash was determined by digestion in 4N hydrochloric acid and burned in a muffle furnace according to the method of Van Keulen and Young (1977).

For serum triglycerides, blood collection was performed at 77, 97 and 112 days of age and analyzes were performed by enzymatic colorimetric method (Labtest Diagnostica).

At the end of experimental period, the animals were weighed and slaughtered after fasting for 15 hours, in a commercial slaughterhouse. After 24 hours, it was measured the carcass weight, carcass yield, carcass length, average backfat thickness, loin depth, fat depth, loin eye area and fat area and calculated the amount of lean meat, lean meat

percentage and fat/meat ratio, according to Bridi and Silva (2007).

Samples of the *Longissimus* muscle of the right half carcass, without the fat layer adjacent, were vacuum packed and stored in a freezer (-10°C) for later determination of color (Minolta CR300 colorimeter, Tokyo), pH, water holding capacity, cooking loss, shear force and reactive substances to the 2-thiobarbituric acid (TBARS) according to Cherian et al. (2007).

To evaluate the economic viability, it was determined the cost of diet per kilogram of live weight gain, according to the equation proposed by Bellaver et al. (1985), calculating the economic efficiency index and the cost index, as proposed by Fialho et al. (1992). The allowance index was calculated from the lean meat percentage and the hot carcass weight, according to Bridi and Silva (2007). It was also determined the value of the pig at the beginning of the experiment, from the initial weight of the animal and the price per kilogram of live weight (R$ 6.70), and at the end of the experiment, considering the allowance index and the hot carcass weight, being calculated the partial gross income and partial net income, considering the feed costs and the value of pig carcasses (Favero et al. 1997).

Data from both trials were submitted to analysis of variance by SAS statistical software. In the metabolism trial, the digestibility of crude protein, ether extract, mineral matter and energy values between 5 and 10% of beef tallow inclusion was compared. In the performance trial, means were compared by Dunnet test at 5% of significance. Serum triglycerides were analyzed in a split plot design, considering the treatments as plots and the collection time as subplots, and means compared by Dunnet test at 5% of significance.

RESULTS AND DISCUSSION

There was no difference between the digestible nutrients and metabolizable energy of beef

tallow (P> 0.05) in both levels of inclusion on metalizability trial (Table II).

The metabolizable energy value of beef tallow was lower than that indicated by Rostagno et al. (2011), which can be related to the lack of standardization of the feedstuff. The moisture content of the tallow remained below 1%, being characterized as appropriate, considering that higher levels can result in a reduction of energy by dilution or by increasing free fatty acids, resulting in lower digestibility of the ingredient (Raber et al. 2009). The coefficient of metabolizability of beef tallow, obtained by the ratio of metabolizable and gross energy values, was 86.39%, higher than the value of 83.82% found by Rostagno et al. (2011).

Regarding the performance (Table III), it was observed significant difference (P <0.05) for feed conversion ratio in the period 2 and total period among animals fed control diet, diet containing 3080 kcal ME/kg with the inclusion of beef tallow without emulsifier and diet containing 2930 kcal ME/kg with beef tallow and emulsifier.

The inclusion of 2% of beef tallow on diet containing 3230 kcal ME/kg in all phases, provided metabolizable energy needed for the development of the animals, resulting consequently in a performance similar to those obtained for pigs fed diets containing soybean oil with the same energetic level. The results agree with those obtained by Kim et al. (2008) that observed higher daily weight gain and better feed conversion ratio of growing pigs

fed diets containing 2.5% beef tallow and soybean lecithin emulsifier, compared to those who received feed without this additive. Thus, the emulsifier addition and the energy density of the diet resulted in distinct effects, because, in this study, the energy of diet containing emulsifier was used by the pigs primarily to compensate the reduction of dietary energy density up to 150 kcal ME/kg, which may correct the nutritional matrix of this feedstuff from the use of this additive in pig diets.

The coefficients of digestibility of nutrients and energy of diets (Table IV) was higher in treatments containing the energy level of 3230 kcal ME/kg, regardless of the lipid source, as well as in the treatment with a reduction of 150 kcal ME/kg containing beef tallow and emulsifier (P<0.001).

Although it was not observed differences in the digestibility of nutrients and energy between the lipid sources in treatments containing 3230 kcal ME/kg (T1 and T2), Mitchaothai et al. (2008) observed higher coefficient of digestibility of ether extract and crude protein in diets containing sunflower oil compared to those containing beef tallow. Similarly, Duran-Montgé et al. (2007) observed that beef tallow showed lower ileal coefficient of digestibility when compared to lipid sources from vegetable origin for growing pigs. Regarding the emulsifier, the results agree with the performance of animals, because the lower digestibility coefficients found for the animals fed diet containing 3080 kcal ME/kg and beef tallow

TABLE II
Nutritional and energetic composition of beef tallow in two evaluated levels for pigs at growing phase.

Composition (DM basis)	Chemical composition	Digestible nutrients and metabolizable energy			CV[2] (%)	P value
		5%	10%	BT[1]		
Dry matter (%)	99.94	94.08	95.78	94.93	9.38	0.8995
Nutrients and energy						
Crude protein (%)	0.03	0.00	0.01	0.005	1.54	0.5402
Ether extract (%)	99.96	93.96	94.53	94.24	8.77	0.5129
Mineral matter (%)	0.40	0.34	0.35	0.34	5.74	0.9304
Gross energy (kcal/kg)	8254.02	7042.13	7219.81	7130.97	4.92	0.1867

[1]BT - beef tallow; [2]CV - coefficient of variation.

TABLE III

Performance of pigs fed diets with variation in energy level, source of lipids, with and without emulsifier addition.

Phase	Treatment	Daily feed intake (kg)	Daily weight gain (kg)	Feed conversion ratio
Period 1 (70 to 90 days)	T1	1.745 ± 0.23	0.793 ± 0.12	2.210 ± 0.12
	T2	1.803 ± 0.16	0.820 ± 0.06	2.196 ± 0.08
	T3	1.858 ± 0.22	0.811 ± 0.06	2.286 ± 0.10
	T4	1.802 ± 0.18	0.832 ± 0.09	2.168 ± 0.07
	T5	1.786 ± 0.13	0.767 ± 0.04	2.330 ± 0.15
	CV (%)[1]	10.58	10.10	4.98
	P value	0.8861	0.7427	0.1488
Period 2 (70 to 105 days)	T1	2.118 ± 0.21	0.880 ± 0.08	2.354 ± 0.15
	T2	2.093 ± 0.20	0.882 ± 0.07	2.370 ± 0.08
	T3	2.206 ± 0.17	0.869 ± 0.02	2.569 ± 0.15*
	T4	2.130 ± 0.14	0.897 ± 0.05	2.373 ± 0.04
	T5	2.111 ± 0.11	0.815 ± 0.05	2.596 ± 0.13*
	CV (%)[1]	7.85	6.53	4.90
	P value	0.7362	0.1373	0.0035
Total period (70 to 150 days)	T1	2.442 ± 0.23	0.902 ± 0.07	2.648 ± 0.08
	T2	2.412 ± 0.22	0.893 ± 0.06	2.645 ± 0.09
	T3	2.522 ± 0.10	0.869 ± 0.02	2.905 ± 0.14*
	T4	2.465 ± 0.07	0.926 ± 0.03	2.662 ± 0.05
	T5	2.453 ± 0.13	0.872 ± 0.05	2.814 ± 0.04*
	CV (%)[1]	6.65	5.56	3.33
	P value	0.7913	0.3291	0.0001

[1]CV - Coefficient of variation; *Means followed by an asterisk in the column differ from the treatment T1 by Dunnet test at 5% of significance.

TABLE IV

Coefficient of digestibility of nutrients and energy of diets for pigs at growing phase, according to energy level, source of lipids, with and without emulsifier addition.

Coefficient of digestibility	Trataments					CV[1] (%)	P value
	T1	T2	T3	T4	T5		
Dry matter (%)	96.31	96.33	95.01*	95.47*	94.92*	0.36	0.0001
Mineral matter (%)	68.59	66.82	63.69*	67.68	61.82*	4.20	0.0024
Gross protein (%)	82.90	83.86	79.92*	81.56	78.73*	2.16	0.0086
Ether extract (%)	71.71	72.79	58.00*	72.67	60.61*	7.22	0.0001
Energy (%)	86.90	86.92	84.92*	85.68	82.72*	1.13	0.0001

[1]CV - Coefficient of variation; *Means followed by the asterisk in the line differs from treatment T1 by Dunnet test at 5% probability.

without adding emulsifier, as well as in those that were fed diets containing 2930 kcal ME/kg containing beef tallow and emulsifier, resulted in worse feed conversion ratio of the animals.

Whereas the main effect of the emulsifier is related to better utilization of dietary lipids, it was observed that the inclusion of the additive resulted in the digestibility of the ether extract similar to the diet containing the soybean oil. Evaluating the addition of 1.5% of emulsifier in diets for pigs containing 6.5% of beef tallow, Reis de Souza et al. (1995) observed an increase in coefficient of digestibility of ether extract, although it was not observed the same effect in digestibility of energy.

Similarly, Soares and Lopez-Bote (2002), observed that the addition of soybean lecithin in piglet diets containing different lipid sources, increased animal fat digestibility, because micelle formation from saturated fatty acids present in the fat is lower, and thus the emulsifier could potentiate the lipid digestion.

The levels of serum triglycerides (Table V) did not differ among treatments (P> 0.05), disagreeing with the results obtained by Park et al. (2009) who observed higher serum triglycerides levels in animals fed diets containing 5% of beef tallow compared to those fed soybean oil, being the divergence justified by the different inclusion levels of beef tallow among studies. According to Klingenberg et al. (1995), the amount of carbohydrates in the diet is the main cause of hypertriglyceridemia, having no effect of lipid sources composed predominantly of C18:n in the diet on the level of plasma triglycerides.

There was no significant difference (P> 0.05) in carcass characteristics and meat quality among treatments (Table VI). Thus, the worst feed conversion ratio in animals fed diet containing 3080 kcal ME/kg and beef tallow without emulsifier addition, and those fed diet containing

TABLE V
Serum triglycerides levels of pigs fed diets with variation in energy level, source of lipids, with and without emulsifier addition.

Trataments	Triglycerides (mg/dL)		
	Period 1	Period 2	Total period
	(70 to 90 days)	(70 to 105 days)	(70 to 150 days)
T1	79.52	73.45	68.73
T2	72.51	70.35	78.68
T3	63.50	54.65	55.75
T4	81.05	63.09	68.22
T5	67.96	59.09	59.97
CV (%)[1]	29.94	28.95	26.18
P value	0.6679	0.2391	0.3141

[1]CV - Coefficient of variation.

TABLE VI
Carcass characteristics and meat quality of pigs fed diets with variation in energy level, source of lipids, with and without emulsifier addition.

Carcass characteristics	Trataments					CV[1] (%)	P value
	T1	T2	T3	T4	T5		
Weight at slaughter (kg)	97,03	95,62	94,78	94,48	95,04	4,48	0,1728
Hot carcass weight (kg)	72,15	70,35	70,45	72,62	69,95	3,40	0,0357
Carcass yield (%)	74,42	73,68	74,36	74,53	72,82	3,00	0,9120
Carcass length (cm)	93,17	93,93	92,83	93,50	92,70	2,16	0,0714
Average backfat thickness (mm)	24,51	24,22	25,25	23,30	21,72	15,56	0,3232
Loin depth (mm)	63,17	60,06	60,98	59,17	60,82	7,07	0,4637
Fat depth (mm)	14,30	14,56	13,41	12,52	10,76	27,81	0,4751
Carcass amount of lean meat (kg)	42,12	40,87	41,53	43,61	42,16	4,02	0,1392
Carcass lean meat percentage (%)	58,02	57,56	58,32	58,63	59,82	3,82	0,6091
Loin eye area (cm²)	38,40	38,90	39,47	36,87	38,40	16,35	0,2334
Fat area (cm²)	17,07	15,50	17,22	15,76	12,68	20,68	0,0127
Fat/meat ratio	0,46	0,44	0,44	0,42	0,34	19,84	0,3306

TABLE VI (continuation)

Carcass characteristics	Trataments					CV[1] (%)	P value
	T1	T2	T3	T4	T5		
L*[2]	58,57	57,94	59,31	58,4	57,98	3,64	0,8010
a*[3]	2,32	3,26	2,47	3,16	3,40	31,14	0,1699
b*[4]	11,26	11,85	11,78	11,90	11,95	8,24	0,7339
pH	5,80	5,70	5,75	5,82	5,76	1,77	0,2851
Water retention capacity (%)	1,35	1,19	1,31	1,34	1,33	8,51	0,1285
Cooking loss (%)	70,85	70,32	69,99	68,55	69,86	3,77	0,6438
Shear force (kgf / cm²)	3,37	4,03	3,25	4,02	3,61	31,06	0,6615
TBARS[5] dia 0(mg/kg)	3,39	3,56	3,09	3,03	3,04	23,15	0,1053
TBARS dia 7 (mg/kg)	6,70	6,99	6,03	6,48	6,89	19,38	0,1248

[1]CV - Coefficient of variation. [2]Lightness. [3]Redness. [4]Yellowness. [5]Thiobarbituric acid reactive substances.

2930 kcal ME/kg, beef tallow and emulsifier, did not result in depreciation in carcass characteristics. Similar results to those found in this study were observed by Mitchaothai et al. (2007) comparing the beef tallow and sunflower oil as lipid sources for finishing pigs, as well as by Park et al. (2009), replacing soybean oil by beef tallow at 5% in barrow diets, noting similar values for loin depth and fat depth between treatments. Comparing beef tallow to used cooking oil, Browne et al. (2013) noted that both lipid sources in diets did not affect the carcass characteristics of pigs. Evaluating the beef tallow, palm oil and glycerol in diets for finishing pigs, Lee et al. (2013) observed that the beef tallow did not decrease carcass characteristics, although it has resulted in lower value of L* value of fat. Considering that the addition of beef tallow in the diet can change the fatty acid profile of pork meat, increasing the composition of saturated fatty acids to the detriment of mono and polyunsaturated, and that the latter are amenable to peroxidation (Apple et al. 2009b), there was no effect of this ingredient and the emulsifier on the TBARS value of the meat.

According to the results of the economic evaluation (Table VII), the economic efficiency index, cost index and the partial net income was significantly lower (P <0.05) for animals fed diet containing 3080 kcal ME/kg with beef tallow without emulsifier and those fed diet with 2930 kcal ME/kg containing beef tallow and emulsifier compared to animals fed diet with soybean oil. On the other hand, animals fed diet with beef tallow and 3230 kcal ME/kg and those fed diet with 3080 kcal ME/kg containing beef tallow and emulsifier,

TABLE VII
Economic evaluation of pigs fed diets with variation in energy level, source of lipids, with and without emulsifier addition.

Variables	Treatments					CV[1] (%)	P value
	T1	T2	T3	T4	T5		
Cost of feeding (R$)	185.91	181.75	184.26	185.95	177.09	7.98	0.7896
Economic efficiency index	97.17	97.19	92.04*	100.00	92.23*	6.13	0.0363
Cost index	100.00	101.76	107.25*	100.51	109.44*	6.49	0.0275
Allowance index	102.26	101.28	102.07	103.35	103.24	2.00	0.5325
Partial gross income (R$)	290.28	275.65	279.20	304.16	273.50	5.92	0.0429
Partial net income (R$)	112.53	113.48	95.64*	111.88	96.41*	9.26	0.0121

[1]CV - Coefficient of variation; *Means followed by an asterisk in the line differs from treatment T1 by Dunnet test at 5% probability.

did not differ from animals fed diet with soybean oil as lipid source.

The difference in economic efficiency index and cost index are related to the worst feed conversion ratio observed in treatments with beef tallow was the lipid source, with dietary energy level reduction of 150 kcal ME/kg without emulsifier and reduction of 300 kcal ME/kg with emulsifier. In this sense, emulsifier inclusion could compensate the reduction of 150 kcal ME/kg but was not effective at higher energy reductions.

CONCLUSIONS

The beef tallow can substitute soybean oil as lipid source in diets for pigs at growing and finishing phases, and the reduction of up to 150 kcal ME/kg in diet within the use of beef tallow can be compensated by emulsifier addition.

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